Symmetrical Dental Occlusion Blocking - What are the Required Changes of Pressure Distribution to be Clinical Relevant?

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Abstract

Background: Symmetrical dental occlusion blocking (bicuspid region) is used in dentistry as a quick diagnostic test ("Meersseman test") to check a possible influence of the temporomandibular system (TMS) on the movement system. Immediate effects between occlusal blocking and rest position on body sway and weight distribution in general and for both genders and for four age decades should be evaluated.

Methods: 725 (396f/329m) healthy subjects (neither subjective signs of TMD nor acute/chronic complaints in the musculoskeletal system) volunteered (21 to 60 years) while both genders were divided into four age groups according to decades. A pressure measuring platform was used. The postural control (body sway and weight distribution) was recorded in two dental occlusion conditions (a) in rest position and (b) symmetrical blocking (bicuspid region) by cotton rolls.

Results: The frontal sway reduced by 0.67mm ($t(724) = -3.9$ ($p < 0.001$)) and the sagittal sway by 0.33mm ($t(724) = -3.4$ ($p < 0.001$)). The relative pressure under the forefoot left increased by 0.33% ($t(724) = 2.88$ ($p < 0.001$)) and the relative pressure overall under the forefoot increased by 0.67% ($t(724) = -3.4$ ($p < 0.001$)). Gender-specific and age-specific reactions cannot be recorded.

Discussion: In all subjects the postural sway improved slightly when blocking the occlusion ("Meersseman test") compared to the rest position. There is a slight shift of weight on the forefoot, especially the left forefoot. There exist no age- and gender-specific differences. Clinically relevant differences should apply outside the data between the 1st and 3rd quantile.

Background

To date, there is no clear scientific rationale for the question of whether temporary changes in dental occlusion affect postural control as several reviews and meta-analyses conclude (1–7). A review by Moon & Lee (7) confirmed that a theoretically neurophysiological connection exists, that allow an influence of the temporomandibular joint (TMJ) on postural stability. Perinetti et al. (1) reported an experimental observed relationship between temporomandibular disorders (TMD) and postural stability, but questioned the clinical significance due to low diagnostic accuracy, and the general low quality of the used study protocols or missing follow-up studies (6). Manfredini et al. (3) and Michelotti et al. (4) raised major concerns on the validity of posturography as diagnostic test in the treatment of temporomandibular disorder. Therefore, both meta-analysis concluded that a cause effect relationship is missing, even though they acknowledge the existence of a relationship between TMD and postural stability.

The posturo-stabilometric parameters as well as the postural sway and the velocity showed acceptable reliability (5, 8). The repeatability of postural variables, like the sway, was confirmed by Ishizaki et al. (9). The influence of the circadian rhythm on the postural stability was also reported (10). Based on a meta-analysis, Perinetti et al. (5) concluded a 25% difference of the sway variables is required to measure a true difference between conditions. An interesting finding is that the influence of the TMD seemed to increase with the difficulty of the balance task (2).

In summary there is increasing evidence, that a relationship between the dental occlusion condition and postural stability exists. The clinical and therapeutically relevance still remains controversial. Furthermore, there is a common agreement, that more research about the clinical relevance is required. A clinical relevant test to detect a temporomandibular dysfunction (TMD) is the Meersseman test (11, 12). The Meersseman test evaluates misalignments of the bite position with a symmetrical dental occlusion blockage with paper stripes. The theoretical concept assumes that blocking the occlusion eliminates the neurophysiological influence of the TMS, which should work fast and temporally. A change of the musculoskeletal system is expected, if a TMD exists. Therefore, within the Meersseman test, patients bite onto paper stripes and the dentist observes the body posture, trying to note any changes. The test is often carried out slightly modified with cotton rolls (11, 12). There exist modified versions of the test, in terms of the variation of the location of the stripes, the stripes themselves and symmetric or asymmetric positioning. The main argument is an influence of the change in the occlusion condition on the postural control system.

Within this study, we investigated the quantitative limits of the Meersseman test. We recruited healthy subjects both, free from signs of a TMD through their whole adult's lifespan and free from subjective signs of acute or chronic complaints or injuries in the entire locomotor system. With this cohort, we tested the Meersseman test in order to achieve a lower bound for the postural stability. A lower bound for the quantitative measurement is important in order to assess the clinical relevance of a specific outcome. For a clinical test not only a change of a measurement larger than the measurement error is required, but also a change that exceeds a physiological, healthy change.

The goal of this study is to measure the change induced with the Meersseman test on the postural stability which was executed with a symmetrical occlusion condition in the bicuspid area. Based on the literature the size of the cohort was calculated. As a post hoc test the confounding factors age and gender were further analysed, to observe any changes throughout the life span. This will lead to a lower bound for a clinical relevant change of a patient.

Methods

Subjects

Based on the study of Baldini et al. (13) the detectable change with the occlusion condition was in the range of a fifth of the standard deviation. With a chosen power of 0.8 and 8 variables (Bonferroni correction of multicomparison) that were of interest, this resulted in a minimal sample size of 324. The second goal of this study is to calculate the lower bounds for clinical relevance. Therefore, we distributed the 324 subjects evenly over the age range from 20 to 60. In addition, we collected the same number of female and male subjects and therefore tried to measure more than 81 subjects in every decade in both the female and male cohort.

In this study, 725 (396f/329 m) healthy subjects volunteered. “Healthy“ means that the subjects have no acute symptoms of TMD or in the movement apparatus and subjectively described themselves as healthy at the time of measurement. Subjects ranged from 21 to 60 years in age for both genders (Table 1). Subjects were equally distributed over every year and a description of the individual decades is presented in Table 1.

Table 1
Biometric distribution of the investigated subjects.

Sex	Age group	Age (Mean ± SD)	n	Height [m]	Weight [kg]	BMI [kg/m^2]
female	21–60	39.69 ± 11.66	396	1.67 ± 0.06	66.46 ± 12.76	23.8 ± 4.6
male	21–60	41.16 ± 11.40	329	1.81 ± 0.07	85.38 ± 14.18	26.1 ± 3.7
female	21–30	25.03 ± 2.68	105	1.69 ± 0.06	60.32 ± 7.87	21.1 ± 2.6
female	31–40	35.12 ± 2.91	101	1.66 ± 0.06	66.82 ± 13.14	24.1 ± 4.6
female	41–50	45.15 ± 2.99	94	1.66 ± 0.07	70.15 ± 15.10	25.4 ± 5.3
female	51–60	55.18 ± 2.92	96	1.67 ± 0.06	69.20 ± 11.90	24.9 ± 4.4
male	21–30	25.19 ± 2.69	81	1.81 ± 0.07	77.66 ± 10.07	23.7 ± 2.4
male	31–40	35.82 ± 2.88	77	1.80 ± 0.07	86.30 ± 12.24	26.8 ± 3.6
male	41–50	55.18 ± 2.92	96	1.67 ± 0.06	69.20 ± 11.90	24.9 ± 4.4
Male	51–60	55.08 ± 2.80	87	1.81 ± 0.08	88.50 ± 14.31	26.9 ± 3.6

According to the World Health Organization (WHO) classification (14), all women are of normal weight, while men are pre-obese. With regard to the age group analysis of the women, they are normal weight up to the age of 40 years and from then on pre-adipose (25.2 and 25.0 kg/m²). In contrast, men are normal weight up to the age of 30 years and from then on pre-obese with 26.7, 26.8 and 27 kg/m² respectively.

All subjects were subjectively healthy without previous postural diseases and/or temporo-mandibular disorders. Before the study conducted, each participant had to sign a written consent and complete a medical history form and anamnesis questionnaire (Centre for Dental, Oral and Maxillofacial Medicine of the Goethe University Frankfurt am Main (15)). The latter included questions on general diseases such as osteoporosis, diabetes mellitus, pain in the joints in general, noises in the ears as well as complaints in the temporomandibular joint. The test persons were also asked about possible accidents in the mouth, jaw and face areas and in the musculoskeletal system.

The study was in accordance with the 1964 Helsinki Declaration and its later amendments and was approved by the local medical ethics committee of the Faculty of Medical Science, Goethe University Frankfurt, Germany (approval No. 303/16).

Measurement system

The pressure measuring platform GP MultiSens (GeBioM GmbH, Münster, Germany) has a measurement area of 38.5 × 38.5 cm, into which 2304 pressure sensors are integrated. The postural control can be measured with a sampling rate of 100 Hz. The sensors are arranged in a quadratic matrix and distributed at a density of 1.5 sensors/cm². The maximum measurement error is ± 5% (according to the manufacturer).

Measure protocol

Each subject was instructed to stand within the circle depicted on the plate, in habitual body position, jaw in rest position and fixing a point at eye level without moving. The postural control was recorded for 30 seconds with a three-time measurement repetition. In order to obtain reproducible values, first three repeated measurements with rest position occlusion situation were performed and afterwards with a symmetrical blocked occlusion in the area of the bicuspids with cotton rolls.

Evaluation of parameters

The weight distribution of the left and right foot and the maximum body sway were recorded. Variables collected were: the amplitude of the frontal sway (mm), the amplitude of the sagittal sway (mm), percentage weight distribution of the four quarters “relative pressure fore foot left”, “relative pressure fore foot right”, “relative pressure rear foot left”, “relative pressure rear foot right”, the sum to the “relative pressure fore foot” and the sum to the “relative pressure left foot” (rear and right was left out because they are the complementary to 100%).

Statistics

Statistical analysis was done in matlab (Version 2018a). Significance was tested using a manova. Prior to the manova data were inspected. Normal distribution was tested with the Lilliefor test (16). In case of none-normal distribution, normal distribution was calculated through the rank transformation of the data. This was done for all variables. The difference of the rank distributed data was calculated and subjected to a manova. The Wilk test was used to evaluate the multiple comparisons. The response of the model were all 8 variables. No independent factors were tested. If significant a post hoc student’s t-test was performed. To check the uniformity of the result over age and gender a second manova was done with the same response variables, however with the sex and age groups (as the decades) as the independent factors (Wilkinson notation: sex + age group + sex:age group). Again as a post hoc test the student’s t-test or a anova was performed. For the post hoc tests a Bonferroni correction was applied. Data where presented as the original data (not rank transformed) for a better understanding. Significance level was set to 0.05.

Results

No variable was normal distributed. Therefore, all variables were transferred to a normal distribution via rank transformation. The manova test on the difference between rest position and cotton roll condition revealed a significant result for at least one variable $F(7,718) = 8.14$ ($p < 0.001$) (Table 2).

Table 2
Result of the manova. Differences could be observed within at least one variable over all subjects and between the sex group.

Within	Between	Statistic	Value	F	R^2	df1	df2	P value
variable	(Intercept)	Wilks	0.927	8.14	0.073	7	718	< 0.001

A student’s t test showed that over all subjects the frontal and sagittal sway were reduced, and the fore foot and the fore foot left are increased for the cotton roll condition (Table 3). The frontal sway reduced by 0.67 mm ($t(724) = -3.9$ ($p < 0.001$)) and the sagittal sway reduced by 0.33 mm (t(724) = -3.4 (p < 0.001)). The relative pressure under the fore foot left increased by 0.33% (t(724) = 2.88 (p < 0.001)) and the relative pressure overall under the fore foot increased by 0.67% (t(724) = -3.4 (p < 0.001)).

Table 3
Descriptive statistics of all the variables over the whole sample size. * behind the variable indicates a significant difference. For all variables the degree of freedom is df = 724.

Variable names	Rest position			Cotton roll			Difference cotton roll – rest position			T - value	P- value
	Median	1st quantile	3rd quantile	Median	1st quantile	3rd quantile	Median	1st quantile	3rd quantile		
Spinal column:											
frontal sway [mm]*	11.33	8.67	15.54	10.67	8.00	14.33	-0.67	-3.00	1.33	-3,90	< 0,001
sagittal sway [mm]*	14.67	10.00	20.00	14.33	10.33	18.67	-0.33	-3.00	2.33	-3,36	< 0,001
Relative pressure forefoot left [%]*	19.33	15.33	23.33	19.67	15.33	24.33	0.33	-1.67	2.00	2,88	< 0,001
Relative pressure forefoot right [%]	15.00	11.00	19.33	15.00	11.00	19.67	0.00	-1.67	1.67	0,49	0,62
Relative pressure rearfoot left [%]	32.33	27.67	36.67	31.67	27.33	37.00	0.00	-2.33	2.08	-1,57	0,12
Relative pressure rearfoot right [%]	32.67	27.67	38.00	32.50	27.00	38.00	0.00	-2.67	2.33	-1,18	0,24
Relative pressure left foot [%]	51.89	47.33	57.00	52.33	47.58	57.00	0.00	-2.00	2.33	1,46	0,14
Relative pressure forefoot [%]*	33.33	28.33	41.00	34.33	28.33	42.00	0.67	-2.00	3.33	3,38	< 0,001

The second manova checked the differences between sex or age decades revealed no difference between either sex, age decade or the interaction of sex and age decade (Table 4). The lowest probability for a difference was found between the two sex groups by p = 0.24.

Table 4
Result of the manova. No difference could be observed between sex, age decades or the interaction of sex and age decade.

Within	Between	Statistic	Value	F	R^2	df1	df2	P value
variable	sex	Wilks	0.99	1.31	0.01	7	715	0.24
variable	Age decade	Wilks	0.99	1.04	0.01	7	715	0.40
variable	sex:age decade	Wilks	0.99	0.84	0.01	7	715	0.56

Discussion

The purpose of this study was twofold. First, we assessed the change of postural control variables with an occlusion condition in a healthy cohort; second, we calculated the required changes in order to measure potential clinical relevant changes.

The blocked occlusion condition introduces small but significant decreases of the frontal and sagittal sway. The frontal sway decreases by 0.67 mm, the sagittal sway by 0.33 mm. In addition, the pressure distribution moves slightly to the front with the blocked occlusion condition. The relative pressure under both fore feet increase by 0.67%, where the dominant leg seems to be the left fore-foot with an increase of 0.33%. Already the healthy, symptom free population has a small change of the pressure distribution with the blocked dental occlusion condition. This is important to note because of its limitation for the clinical test.

A possibility to gain a brief insight into whether disturbances of the TMS have an effect on postural control is the Meersseman test. In short, the Meersseman test predicts a TMD, if a change of the postural control can be observed. As we have shown, already the healthy, symptom free population does show a change of the measureable variables with the blocked occlusion. For a clinical relevant outcome the observed changes have to be outside the range of the 1st to 3rd quartile (Table 3). For instance, the frontal sway has to be smaller than 3 mm or larger than 1.33 mm with the blocked occlusion condition compared to rest position to be clinical relevant. The minimal changes of Table 3 can be used for both sex and any age decade, as no gender or age specific differences were measured.

While the clinical relevant assessment was done the first time in this study, many researches was conducted to evaluate effects of occlusion conditions on the pressure distribution (13, 17–19). Bracco et al. (17) measured a reduction in body sway with a myocentric jaw position that is comparable with the values presented in this study. The influence of an occlusion condition is by far smaller than other interventions like closed eyes according to Baldini (13). Contrary to our results, Amaricai et al. (18) could not observe any change of the weight distribution between the rest position and any symmetrical occlusion condition. Also a recent study by Michalakis et al. (19) measured significant changes in the lateral direction (sagittal sway) but no changes in the anterior posterior direction. They study involved only 20 subjects (14 m/6f) and they only counted the number of subjects that showed a change.

Several explanations are discussed in the scientific literature to give a theoretical explanation of the observed phenomena. The most common explanations can be categorized in two categories, sensory dependent theory (7, 20) and mechanical dependent theory (21, 22). The sensory dependent theory states, that missing sensory information in the occlusion condition alters brain circuits, that lead subsequently to a change of the motor pathways (7, 20, 23, 24). The mechanic dependent theory states that either a relaxation of muscles of the anterior triangle or a change of the air tunnel lead to a repositioning of the head and therefore leads to a change of body positioning and subsequently to a change of the pressure distribution (21, 22, 25, 26). Unfortunately, to date none of the theories has been investigated more deeply.

Based on the presented results the change between rest position and blocked occlusion is independent of differences between gender and age. It has been reported, that male subjects have a larger postural sway than female subjects do (27–29) and that the postural stability does decrease with age (30, 31). However, this did not affect the influence of the occlusion conditions´ change. Additionally, we have found no difference between any age and gender group for the change of the pressure variables measured. The body mass and body mass index (BMI) of the cohort has been compared with the general German distribution (32, 33). Only marginal differences in any age or gender group could be found. Even though weight might be another cofactor, the results in terms of the clinical relevance match the population and are therefore representative.

There are some limitations of this study. The inclusion criteria are healthy subjects free of TMD symptoms. For the assessment of the TMD a standardized questionnaire was used (15). Qualified orthodontists/dentists evaluated this questionnaire and discussed open questions in an interview. No excessive dental/orthodontic or orthopaedic examination was undertaken. While this is a common procedure to get a first insight in TMD, it might be a source of incorrect diagnosis. In this study only the correlation between the change of the occlusion condition (between rest position and symmetrical blocked occlusion) and spatial pressure parameters was evaluated. This is obviously no investigation of a cause effect relationship, nor does this study address the theoretical background. New studies should be conducted, that investigate more the principal mechanism behind occlusion interventions. Several research reviews and meta-analysis have shown that a change of the occlusion condition can affect the remaining body, however a deeper understanding of the underlying mechanism is required to optimise the interventions (1–7). For instance, a time dependent analysis of the COP path might be useful to determine if the control strategy and therefore the sensory pathway is effected with a change of the occlusion condition (34).

This study shows, that already in the healthy symptom free population a Meersseman test provokes a small but measureable change of the body sway and pressure distribution. A TMD might therefore not be the only source for a change of these parameters. In addition, the changes are general small and might be influenced strongly by other factors as vision and cognitive workload. Therefore, it has to be questioned if the Meersseman test is clinical relevant. Of course, within this study only healthy symptom free subjects were evaluated. Another study has to be conducted with TMD patients in order to proof, if the test can predict any TMD correctly, without having too many false positive. In an individual assessment, the range of the pressure values for the healthy, symptom free population has to be considered.

Conclusion

Healthy, TMD symptom free subjects show small changes in postural sway and pressure distribution when biting symmetrically on a cotton roll. These changes are independent of age or gender. However, the changes are minor especially compared against the distribution of these parameters in the population. For a clinical relevant assessment of effects of TMD on the pressure distribution, the changes have to be at least outside the 1st and 3rd quantile.

Declarations

Ethics approval and consent to participate

All participants sign an informed consent participate in this study. The study is approved by the Ethics committee of the Department of Medicine of the Goethe University Frankfurt am Main (303/16).

Consent for publication:

Not applicable.

Availability of data and materials:

Not applicable.

Competing interests:

The authors declare that they have no competing interests.

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Authors’ contributions

CMG, GO, DAG and DO made substantial contributions to the conception and design of the manuscript. CMG, IA, FA, WC, CD, VF, VF, AG, JG, UK, JK, DK, JP, LP, CW, BS, PS and DO made substantial contributions to the construction of the measurement protocol. CMG made substantial contributions to the data analysis. CMG, GO, DAG and DO made substantial contributions to the writing of the manuscript. All authors have read and approved the final manuscript.

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